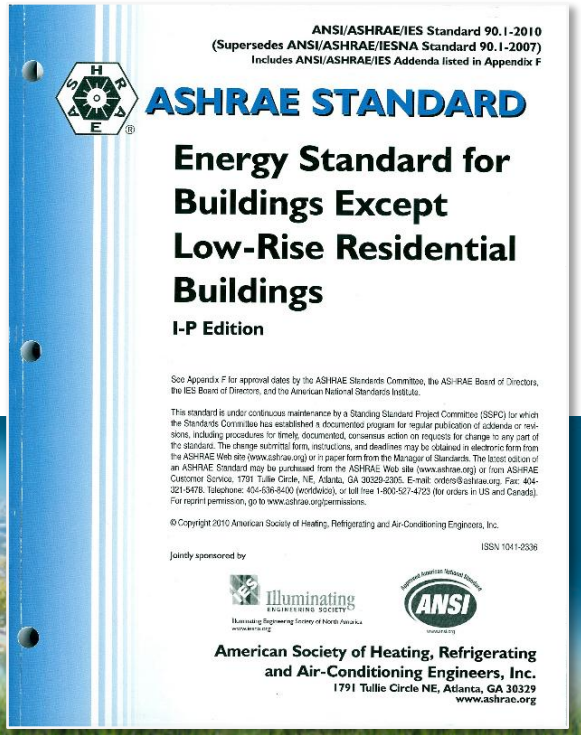
ANSI / ASHRAE / IESNA Standard 90.1 – 2010

Part 3 - HVAC Provisions
(Section 6, 1st half)



Presented by

Energy Systems Laboratory
Texas Engineering Experiment Station
The Texas A&M University System

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Acknowledgments

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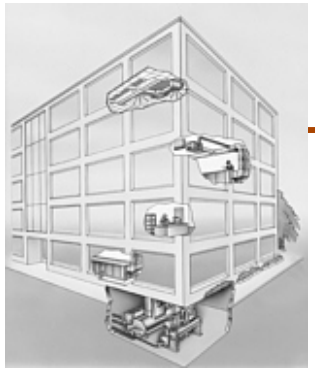
Mechanical Systems: HVAC Compliance

Section 6



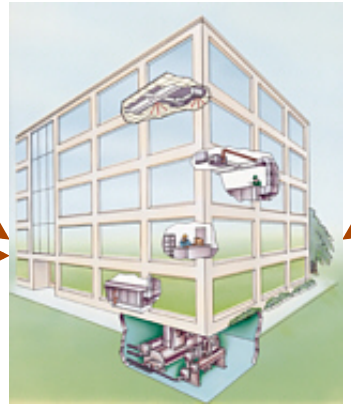
proposed HVAC design

Mandatory Provisions (6.4)

Prescriptive Path (6.5)

Energy Cost Budget (11)

Simplified Approach (6.3)



90.1-compliant HVAC system

Simplified Approach Option for HVAC Systems

Section 6.3

Simplified Approach

Limited to…

Buildings with 1 or 2 stories and with < 25,000ft^2, and that meet 17 criteria:

a. **Single-zone systems.**

b. **VAV controls to ½ of design cfm.**

c. **Air-cooled or evaporatively-cooled unitary/ split per Tables 6.8.1A, B, D.**

d. **Economizer required per Table 6.5.1**
But, economizer requirement can be exempted by conditions in Table 6.3.2

e. **Heating required per Tables 6.8.1B, D, E, F.**

f. **Meet exhaust energy recovery req'mts of Section 6.5.6.1, at ≥ 50% efficiency.**

g. **Manual changeover or dual set-point thermostat.**

Simplified Approach Option for HVAC Systems

Section 6.3, Continued

Simplified Approach

h. Controls on supplemental heaters on heat pumps.

i. Prevent reheat or simultaneous heating and cooling for humidity control.

j. Time clocks (except hotel/motel…); required for systems > 15,000 Btu/h and supply fan > ¾ horsepower. More details in Section 6.3.2, part j.

k. Pipe insulated per Tables 6.8.3A and 6.8.3B.

l. Ductwork and plenums insulated per Tables 6.8.2A & 6.8.2B and sealed in accordance with Section 6.4.4.2.1.

m. O.A. and exhaust systems, shutoff controls, damper leakage, etc. in accordance with Section 6.4.3.4. Motorized auto-shut dampers when spaces served are not in use.

n. Ducted system to be air balanced to industry standards.

o. Interlocked t-stats to prevent simultaneous heating and cooling.

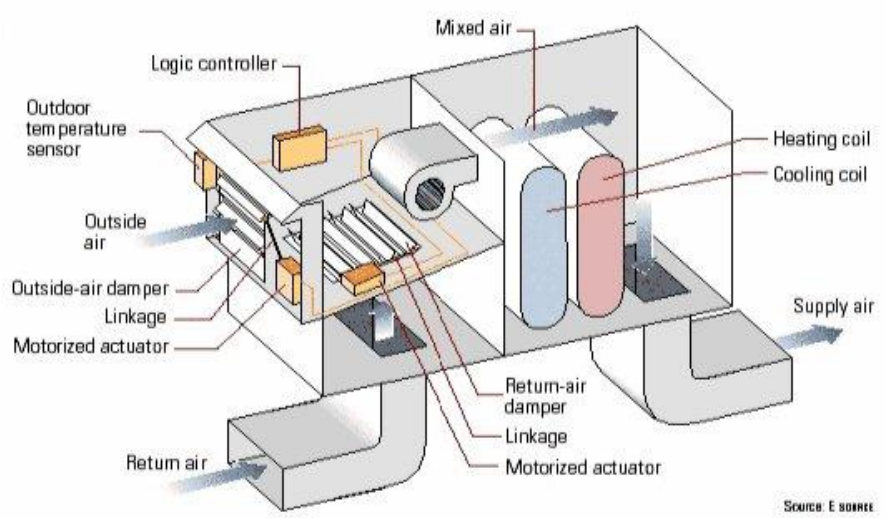
p. Optimum start controls (design supply air capacity > 10,000 cfm).

q. DCV that complies with Section 6.4.3.9.

Economizers (Comfort Cooling)

Table 6.5.1A

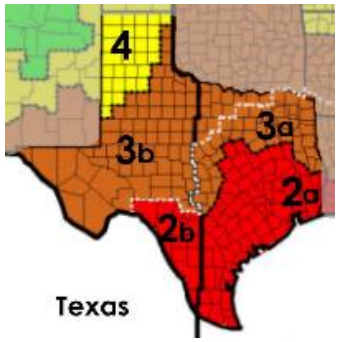
Climate zone	Cooling capacity for which an economizer is required
1a, 1b (Miami, Honolulu)	**Economizer not required**
2a, 2b, 3a, 3b, 4a,5a, 6a, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8 (All of Texas and rest of the U.S.)	**≥ 54,000 Btu/h**

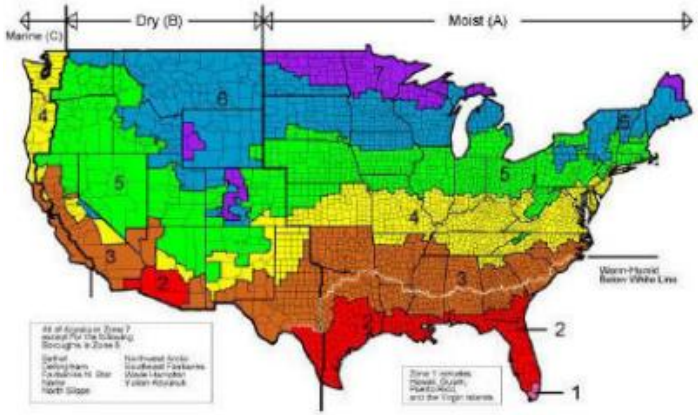


Economizers (computer rooms)

Table 6.5.1B

Climate zone	Cooling capacity for which an economizer is required
1a, 1b, 2a, 3a, 4a (Austin, Houston, Miami, St. Louis, Wash. DC)	**Economizer not required**
2b, 5a, 6a, 7, 8 (Del Rio, Yuma, Chicago, Edmonton)	**≥ 135,000 Btu/h**
3b, 3c, 4b, 4c, 5b, 5c, 6b (Dallas, El Paso, Denver, Seattle)	**≥ 65,000 Btu/h**





Air Economizer Exemption

Section 6.5.1

Required in all zones from 2a through 8, except in Data Centers.

Exemptions are based on increased HVAC Efficiencies, as shown i Table 6.3.2

Table 6.3.2 Eliminate Required Economizer for Comfort Cooling by Increasing Cooling Efficiency

Climate Zone	Efficiency Improvement[a]
2a	17%
2b	21%
3a	27%
3b	32%
3c	65%
4a	42%
4b	49%
4c	64%
5a	49%
5b	59%
5c	74%
6a	56%
6b	65%
7	72%
8	77%

[a] If a unit is rated with an IPLV, IEER or SEER then to eliminate the required air or water economizer, the minimum cooling efficiency of the HVAC unit must be increased by the percentage shown. If the HVAC unit is only rated with a full load metric like EER or COP cooling then these must be increased by the percentage shown.

Mech. Equipment Efficiency Standard Conditions

Section 6.4.1.1

Table 6.8.1A – Air conditioners and condensing units

Table 6.8.1B – Heat pumps

Table 6.8.1C – Water chillers

Table 6.8.1D – PTAC and PTHP

Table 6.8.1E – Furnaces, duct furnaces, and unit heaters

Table 6.8.1F – Boilers

Table 6.8.1G – Heat rejection equipment

Table 6.8.1H – Heat transfer equipment (liquid-to-liquid HX)

Table 6.8.1 I – Variable Refrigerant Flow (VRF) A.C.

Table 6.8.1J – VRF air-to-air & applied heat pumps

Table 6.8.1K – A.C serving computer rooms

All furnaces with input ratings ≥ 225,000 Btu/h, including electric furnaces, that are not located in the conditioned space shall have jacket losses ≤ 0.75% of the input rating"

Mech. Equipment Efficiency Standard Conditions

Section 6.4.1.1

Table 6.8.1A (partial)
Air Conditioners and Condensing Units –Efficiency Requirements

Equipment type	Size category	Heating section type	Sub-category or rating condition	Minimum efficiency
Air conditioner, air cooled	≥ 65,000 Btu/h & <135,000 Btu/h	Elec. Resistance (or none)	Split system & single package	11.2 EER 11.4 IEER
		All others	Split system & single package	11.0 EER 11.2 IEER
	<65,000 Btu/h	All	Split System	13.0 SEER
			Single Package	13.0 SEER
Through-the-wall, air cooled	<30,000 Btu/h	All	Split System	12.0 SEER
			Single Package	12.0 SEER
Air conditioner, water cooled	<65,000 Btu/h	All	Split system & single package	12.1 EER 12.3 IEER

Water Chilling Packages

Section 6.4.1.1

Table 6.8.1C (partial) – Minimum Efficiency Requirements

Equipment Type	Size Category	Units	Path A		Path B	
			Full load	IPLV	Full load	IPLV
Air Cooled, with condenser, Electrically operated	<150 tons	EER	≥9.562	≥12.50	NA	NA
	≥150 tons	EER	≥9.562	≥12.75	NA	NA
Water cooled, elec. operated, positive displacement, rotary or reciprocating	<75 tons	kW/ton	≤0.780	≤0.630	≤0.800	≤0.600
	75-150 tons	kW/ton	≤0.775	≤0.615	≤0.790	≤0.586
	150-300 tons	kW/ton	≤0.680	≤0.580	≤0.718	≤0.540
	≥300 tons	kW/ton	≤0.620	≤0.540	≤0.639	≤0.490
Water cooled, elec. operated, centrifugal	<150 tons	kW/ton	≤0.634	≤0.596	≤0.639	≤0.450
	150-300 tons	kW/ton	≤0.634	≤0.596	≤0.639	≤0.450
	300-600 tons	kW/ton	≤0.576	≤0.549	≤0.600	≤0.400
	≥600 tons	kW/ton	≤0.570	≤0.539	≤0.590	≤0.400
Water cooled absorption, single effect	All sizes	COP	≥0.700	NR	NR	NR

Warm Air Furnaces & Unit Heaters

Section 6.4.1.1

Table 6.8.1E (partial)
Warm Air Furnaces and Combination Warm Air Furnaces/Air-Conditioning Units, Warm Air Duct Furnaces and Unit Heaters

Equipment Type	Size Category (Input)	Sub-category or Rating Condition	Minimum Efficiency
Warm-Air Furnace, Gas-fired	< 225,000 Btu/h	Maximum Capacity	78% AFUE or 80% E_t
	≥ 225,000 Btu/h	Maximum Capacity	80% E_t
Warm-Air Duct Furnaces, Gas-fired	All sizes	Maximum Capacity	*80% E_c*

Notes: AFUE = annual fuel utilization efficiency
E_t = thermal efficiency
E_c = combustion efficiency (100% - flue losses)

Computer Room HVAC

Section 6.4.1.1

Table 6.8.1K Air conditioners & condensing units serving computer rooms

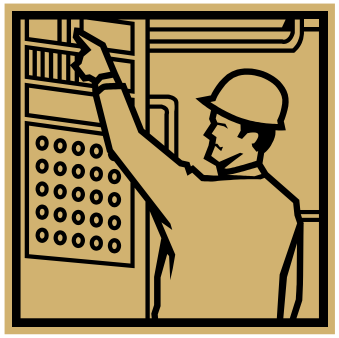
Air Conditioner Equipment Type	Sensible Cooling Capacity (Btu/h)	Min. SCOP-127* Downflow / Upflow Units
Air cooled	<65,000 65,000 – 240,000 ≥ 240,000	2.20 / 2.09 2.10 / 1.99 1.90 / 1.79
Water cooled	<65,000 65,000 – 240,000 ≥ 240,000	2.60 / 2.49 2.50 / 2.39 2.40 / 2.29
Water cooled with fluid economizer	<65,000 65,000 – 240,000 ≥ 240,000	2.55 / 2.44 2.45 / 2.34 2.35 / 2.24
Glycol cooled (40% propylene glycol)	<65,000 65,000 – 240,000 ≥ 240,000	2.50 / 2.39 2.15 / 2.04 2.10 / 1.99
Glycol cooled (40% propylene glycol) with fluid economizer	<65,000 65,000 – 240,000 ≥ 240,000	2.45 / 2.34 2.10 / 1.99 2.05 / 1.94

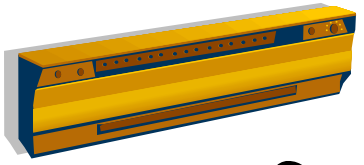
**** SCOP = Sensible Coefficient of Performance == sensible cooling capacity (Watts) / total input power (Watts)***

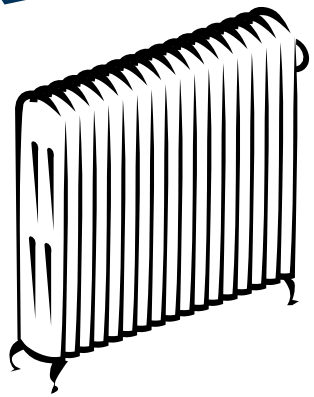
Load Calculations

Section 6.4.2.1

"Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with ANSI/ASHRAE/ACCA Standard 183-2007, Peak Cooling and Heating Load Calculations in Buildings Except Low-Rise Residential Buildings."



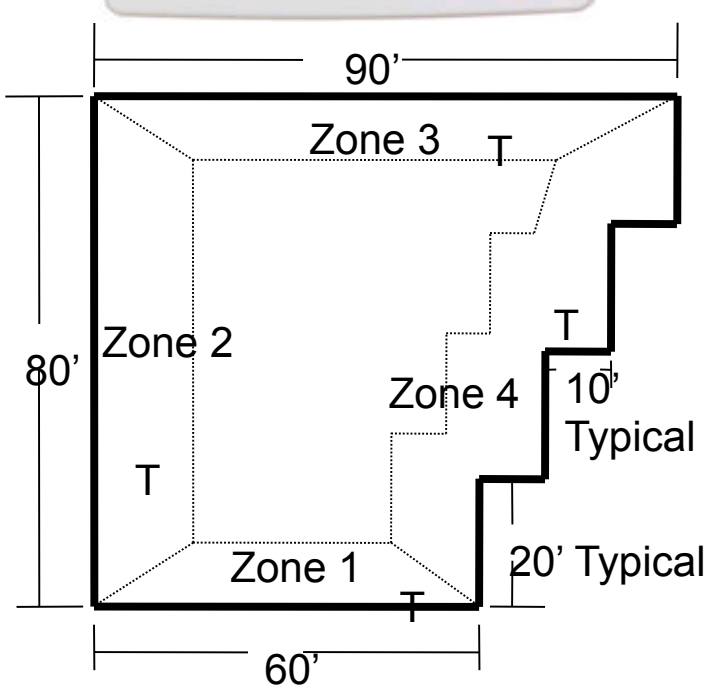




HVAC Controls

Section 6.4.3

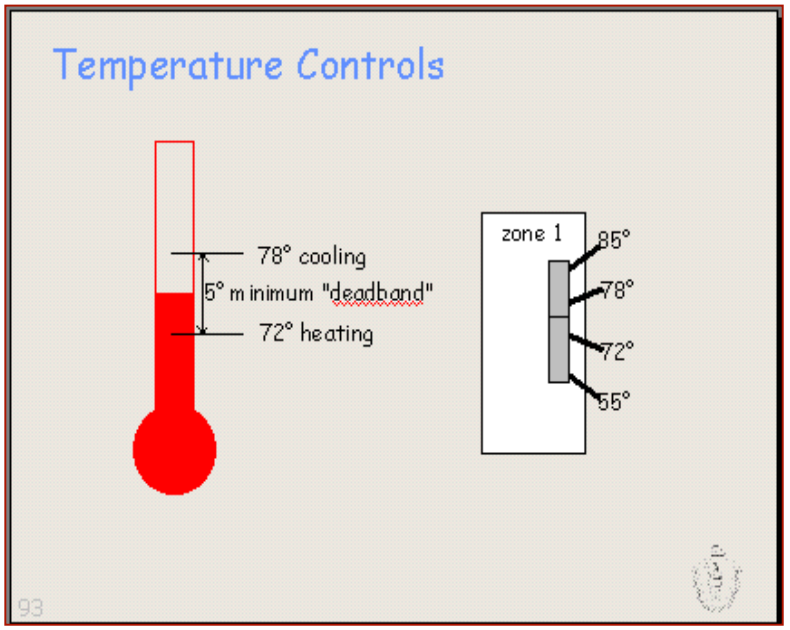
- **Zone Thermostatic controls** ***(Sections 6.4.3.1 & 6.4.3.1.2)***
  - Required for each zone (except a dwelling unit is considered 1 zone)
  - Dead Band controls
  - Set Point Overlap Restrictions
- **Off-Hour controls** ***(Section 6.4.3.3)***
  - Automatic Shutdown
  - Setback Controls
  - Optimum Start Controls
  - Zone Isolation
- **Exceptions**
  - Systems that operate continuously
  - Systems < 15,000 Btu/h capacity



Thermostat Dead Band

Section 6.4.3.1.2

- **Thermostats must have a dead band of at least 5°F.**
- **Exceptions**
  - "Thermostats that require manual changeover between heating and cooling modes.
  - Special occupancy or applications where wide temperature ranges aren't acceptable" (e.g., museums, retirement homes) and are approved by adopting authority.



Setback Controls

Section 6.4.3.3.2

- Applies to heating systems located in climates zones 2 – 8, with heating set point adjustable to 55°F. (Texas climate zones 2, 3, 4)
- Applies to cooling systems in climate zones 1b, 2b, & 3b, with set point adjustable to at least 90F, or to prevent high space humidity levels.
- Exception
  - ➢ "Radiant floor and ceiling heating systems"

✓ ***Note: There is no climate zone "1b" in the U.S.***

Ventilation Shutoff Damper Controls

Section 6.4.3.4.2

- "All o.a. intake & exhaust systems shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use"
- Exceptions:

  a. Gravity dampers o.k. in buildings:
     - < 3 stories in height above grade.
     - All bldgs in climate zones 1, 2, and 3.
  b. Gravity dampers o.k. in systems with a design o.a. intake of ≤300 cfm.
  c. Dampers not required in Ventilation systems serving unconditioned spaces
  d. Dampers not required in systems serving Type 1* kitchen hoods.

**** Type 1 is for exhausting air from cooking equipment that produces heat and grease laden effluent.***

Damper Leakage

Section 6.4.3.4.3

[Where o.a. supply and exhaust/relief dampers are required, they shall have a maximum leakage rate (per AMCA Standard 500) as shown in this table.]

TABLE 6.4.3.4.3 Maximum Damper Leakage (cfm per ft^2 at 1" w.g.)

Climate Zone	Ventilation Air Intake		Exhaust/Relief	
	Non-motorized	Motorized	Non-motorized	Motorized
1,2 Any height	--- 20	--- 4	--- 20	--- 4
3 Any height	--- 20	--- 10	--- 20	--- 10
4, 5b, 5c < 3 stories ≥ 3 stories	--- Not allowed Not allowed	--- 10 10	--- 20 Not allowed	--- 10 10
5a, 6, 7, 8 < 3 stories ≥ 3 stories	--- Not allowed Not allowed	--- 4 4	--- 20 Not allowed	--- 4 4

Ventilation Fan Controls

Section 6.4.3.4.4

- "Fans with motors > ¾ h.p. (0.5 kW) shall have automatic controls complying with section 6.4.3.3.1 that are capable of shutting off fans when not required *."
  - *Exception: HVAC systems that operate continuously.*

*** Section 6.4.3.3.1 (automatic shutdown of HVAC systems) stipulates either: time schedule controls, occupant sensors, adjustable timer, or interlock to a security system that shuts system off when security system is activated.**

Enclosed Parking Garage Ventilation

Section 6.4.3.4.5

"Enclosed parking garage ventilation systems shall automatically detect contaminant levels and stage fans or modulate fan airflow rates to 50% or less of design capacity provided that acceptable contaminant levels are maintained."

NEW!

Exceptions:

a. *Garages <30,000 ft^2 with ventilation systems that do not utilize mechanical heating or cooling.*
b. *Garages that have an area-to-horsepower ratio that is > 1500 ft^2/hp and do not utilize mechanical heating or cooling.*
c. *Where not permitted by the authority having jurisdiction.*

Heat Pump Auxiliary Heat Control

Section 6.4.3.5

Heat pumps equipped w/ internal electric resistance heaters shall have controls that prevent supplemental heater operation when the heating load can be met by the heat pump alone. Supplemental heater operation is permitted during outdoor coil defrost cycles.

Exception: Heat pumps whose minimum efficiency is regulated by NAECA and whose HSPF meets the Table 6.8.1B requirements and includes all usage of internal electric resistance heating.

Ventilation Control for High Occupancy

Section 6.4.3.9

Demand control ventilation (DCV*) required for spaces > 500 ft^2 and > 40 people / 1000 ft^2 that are served by any of these:

a. Air-side economizer, or
b. Auto modulation of O.A. damper, or
c. Design O.A. air flow > 3000 cfm

(Must maintain rates per ASHRAE Standard 62.1)

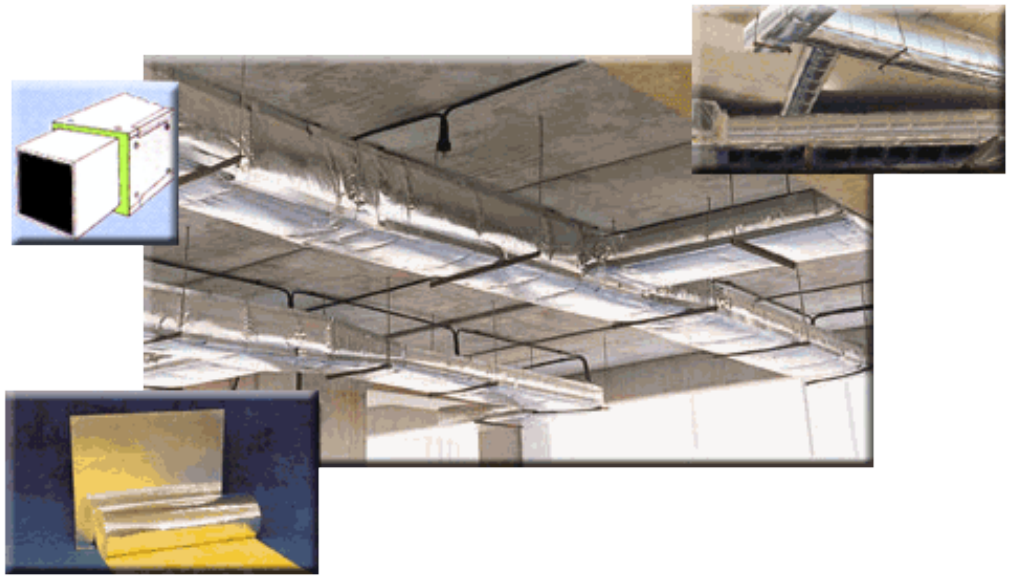
- ***Exceptions:***
  a. Exhaust energy recovery system per section 6.5.6.1.
  b. Multiple-zone systems w/o DDC of individual zones.
  c. Design O.A. < 1200 cfm
  d. Where supply air – makeup air < 1200 cfm.

* CO_2 Sensor/controller => considered best method.

Duct & Plenum Insulation

Section 6.4.4.1.2

- All supply and return ducts and plenums to be insulated per Tables 6.8.2A and 6.8.2B
- Four exceptions (next slide)



Duct & Plenum Insulation

Section 6.4.4.1.2

Four exceptions:

(a) "Factory-installed plenums, casings, or ductwork furnished as part of HVAC equipment

(b) Ducts or plenums located in heated, semi-heated, or cooled spaces

(c) For runouts < 10 ft in length to air terminals or air outlets, the R-value need not exceed R-3.5

(d) Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas > 5 ft^2 need not exceed R-2; those ≤ 5 ft^2 need not be insulated"

Minimum Duct Insulation R-value

Table 6.8.2B

(For heating and cooling combo ducts)

Climate Zone	Duct Location						
	Exterior	Ventilated attic	Unvented attic above insul. clg.	Unvented attic w/ roof insulation	Un-conditioned space	Indirectly conditioned space	Buried
Supply ducts							
1	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
4	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
5	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
6	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
7	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
8	R-8	R-8	R-8	R-1.9	R-6	none	R-6
Return ducts *							
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none

Piping Insulation

Section 6.4.4.1.3

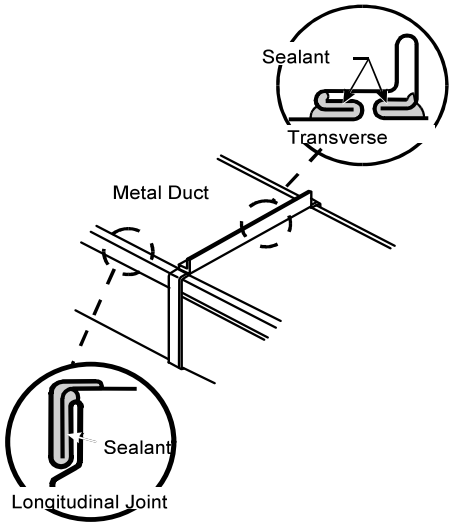
- **Must meet requirements in Tables 6.8.3A & 6.8.3B.**
  - Minimum pipe insulation thickness based on fluid design operating temperature range, insulation conductivity, nominal pipe or tube size, and system type (Heating, SWH, Cooling)

- **Exceptions:**
  a. Factory-installed piping within HVAC equipment.
  b. Piping conveying fluids between 60^0F and 105^0F'
  c. Piping conveying fluids not heated or cooled with purchased energy (such as roof & condensate drains, nat. gas piping, etc.)
  d. Where heat gains or losses will not increase energy use (such as the case with liquid refrigerant piping.)
  e. Strainers, control & balancing valves in pipes ≤ 1" diameter.

Duct Sealing

Section 6.4.4.2.1

- Ductwork and all plenums with pressure class ratings shall include sealing of all transverse joints, longitudinal seams, and duct wall penetrations.
- Meet requirements of 6.4.4.2.2 (leakage tests.)
- Standard industry practice as defined in Appendix E.
- Duct tape or other pressure-sensitive tape shall not be used as the primary sealant unless certified to comply with UL-181A or UL-181B by an independent testing laboratory.



Duct Leakage Tests

Section 6.4.4.2.2

- For ductwork designed > 3 in. w.c. and all ductwork located outside:
  - Leak tested per standards in Appendix E.
  - Representative sections ≥ 25% of the total installed duct area shall be tested.
  - Duct ratings that are > 3 in. w.c. to be identified on drawings.
  - Maximum permitted duct leakage shall be calculated and specified, per next slide --

Permitted Duct Leakage

Section 6.4.4.2.2

"The maximum permitted duct leakage shall be:

$$L_{\max} = C_L P^{0.65}$$

where,

L_{max} = maximum permitted leakage in cfm/100 ft^2 duct surface area"

C_L = leakage class, cfm/100 ft^2 @ 1" w.c.

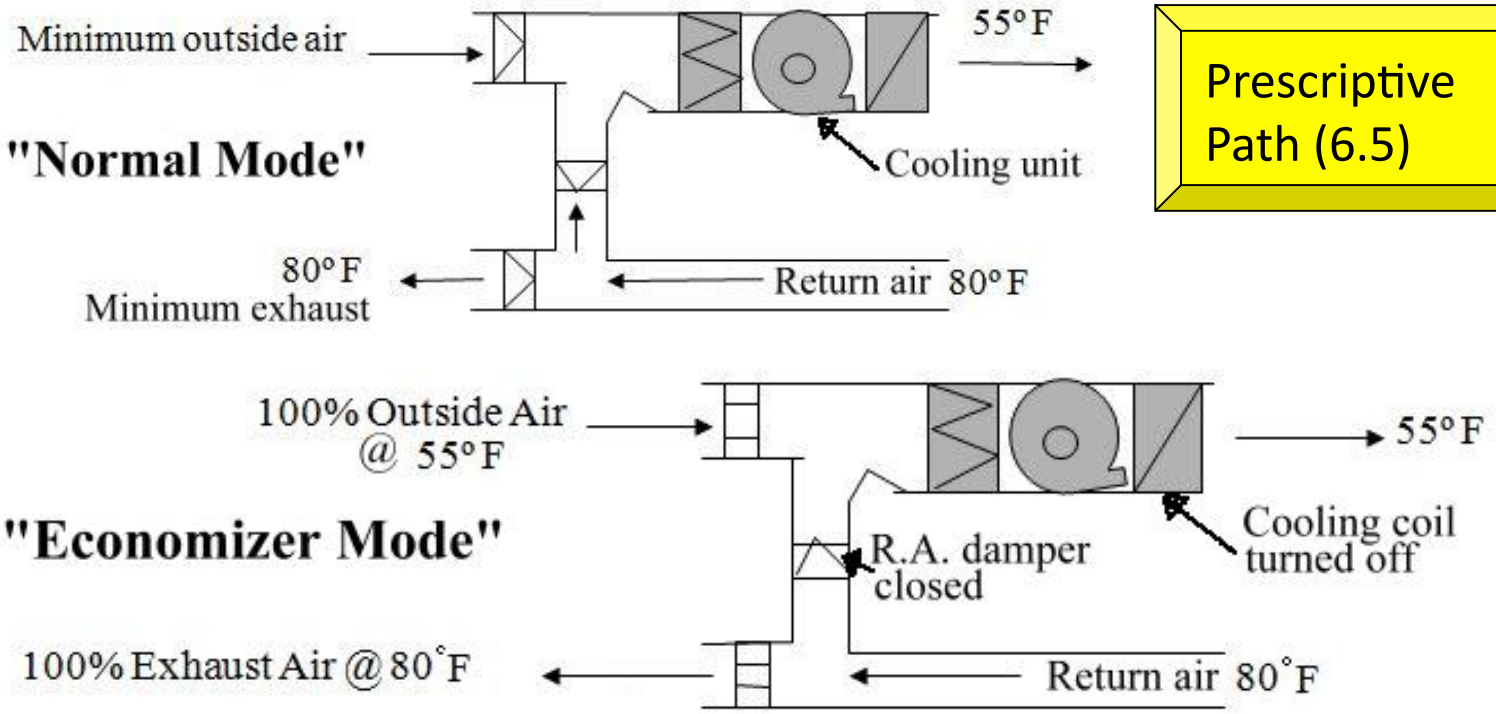
(= 4 for rectangular or round duct.)

P = Test (design) pressure, in " w.c.

Economizer - Design Capacity

Section 6.5.1.1.1

"System capable of modulating outside air and return air dampers to provide up to 100% of the design supply air quantity as outside air for cooling"



Prescriptive Path (6.5)

High Limit Shutoff

Section 6.5.1.1.3

- Automatically reduce *outdoor air* intake to the design minimum *outdoor air* quantity when outside air intake will no longer reduce cooling energy usage”
- High-limit shutoff control types for specific climates from Table 6.5.1.1.3A
- High-limit settings from Table 6.5.1.1.3B

Air Economizer Controls High-limit Shutoff Settings

Table 6.5.1.1.3A

Table 6.5.1.1.3A

Climate zones	Allowed control types	Prohibited control types
1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8	Fixed dry bulb (DB) Differential dry bulb Electronic enthalpy* Differential enthalpy DP and DB temperature	Fixed enthalpy
1a, 2a, 3a, 4a	Fixed enthalpy Electronic enthalpy* Differential enthalpy DP and DB temperature	Fixed dry bulb Differential dry bulb
All other climates (i.e., 5a, 6a)	Fixed dry bulb (DB) Differential dry bulb Fixed enthalpy Electronic enthalpy* Differential enthalpy DP and DB temperature	
* Combines humidity and dry-bulb temperature in its switching algorithm		

Air Economizer Controls High-limit Shutoff Settings

Table 6.5.1.1.3B

Fixed DB

Device type	Climate	Required high limit (economizer off when..)	
		Equation	Description
Fixed DB	1b,2b,3b,3c,4b,4c, 5b,5c,6b,7,8	T_{OA} > 75F	OA temp. exceeds 75F
	5a,6a	T_{OA} > 70F	OA temp. exceeds 70F
Differential DB	1b,2b,3b,3c,4b,4c, 5b,5c,6a,6b,7,8	$T_{OA} > T_{RA}$	OA temp exceeds return air temp
Fixed enthalpy	2a,3a,4a,5a,6a	h_{OA} > 28 Btu/lb	OA enthalpy exceeds 28 Btu/lb.
Electronic enthalpy	All	(T_{oa}, RH_{oa}) >A	OA temp/RH exceeds the "A" set point curve.
Differential enthalpy	All	$H_{OA} > H_{RA}$	Outdoor enthalpy exceeds return air enthalpy
DP and DB temp.	All	DP_{OA} > 55F or T_{OA} > 75F	Outdoor DP exceeds 55F (65 gr/lb.) or outdoor DB > 75F

Economizer Exemptions

Section 6.5.1

a. Individual fan-cooling systems with supply capacities less than those listed in the previous Tables 6.5.1A (comfort cooling) and 6.5.1B (computer rooms.)
b. Systems that include nonparticulate air treatment (per Standard 62.1.)
c. In hospitals and ambulatory surgery centers, if ≥ 75% of air supply is to spaces humidified to >35F dew-point temp.
d. Systems that include a condenser heat recovery system for service water heating.
e. Most residential spaces.
f. Spaces where sensible cooling load is ≤ transmission + infiltration losses at OA of 60F.
g. Systems that operate < 20 hours per week.
h. Where use of OA for cooling will affect supermarket refrigerated casework systems.
i. Where the cooling system efficiency meets or exceeds Table 6.3.2 (shown earlier.)
j. Certain computer rooms, where:
    1. Total cooling load < 3,000,000 Btu/h (not served by chilled water), or
    2. Room cooling load < 600,000 Btu/h (served by chilled water), or
    3. Local water authority does not allow cooling towers, or
    4. Less than 600,000 Btu/h cooling capacity is added in an existing building.
k. Dedicated systems for a computer room, where 75% of load serves:
    1. Spaces classified as an “essential facility.”
    2. Spaces having mechanical cooling design of Tier IV.
    3. Spaces defined by NFPA 70 as “critical operations power systems (COPS).”
    4. Spaces certified to contain critical financial transactions.

This Concludes:
ANSI / ASHRAE / IESNA Standard 90.1 – 2010
Part 3 - HVAC Provisions (1st half)

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